

# RECOVERY OF VOLATILE APPLE FLAVORS IN ESSENCE FORM

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## INTRODUCTION

In the preparation of bland apple sirup<sup>4</sup> and commercial apple concentrates,<sup>5</sup> the volatile flavoring constituents of the fresh juice, which give the natural bouquet, are completely lost. Previous attempts to recover these flavors, made both in this country and in other countries during the past 20 years, have not been completely successful because either some of the more volatile components were lost or in the course of recovery the initial fresh flavor was inadvertently altered. A comparatively simple method for completely recovering the natural flavor of fresh apples in an unaltered form is described here. This product is termed apple essence.

Apple essence is a colorless water solution of the volatile constituents of natural apple flavor concentrated from 100- to 150-fold. Even in this concentrated state, however, the actual proportion of flavoring constituents in the solution does not exceed a few tenths of one per cent by weight. The odor is mildly pungent, a characteristic common to concentrated flavoring essences. No perceptible changes occur in the product during storage of one and a half years; apparently it will keep indefinitely if the container is kept tightly stoppered.

Blending the essence with a good grade of filtered apple juice that has been concentrated by vacuum evaporation results in a full-flavored apple juice concentrate, which when reconstituted with water, is indistinguishable in taste and aroma from fresh apple juice.

A process for essence recovery is illustrated in Figure 1, which also

shows the general characteristics of a plant having an hourly capacity of 1,000 gallons of juice. The process consists of the following steps: (1) quickly vaporizing 10 per cent of the juice, (2) mechanically separating the vapors from the unvaporized portions of the juice, and (3) fractionating the vapors to obtain a more concentrated flavor.

## Preparing the Juice

The juice may be pressed from cull apples, but they must be sound because any volatile off-flavors in the juice are also recovered. Since the characteristics of the flavor, including the aroma, are dependent upon the variety of apples used, blending different varieties should be taken into consideration as a means for controlling and improving the flavor of the product. McIntosh, Jonathan, Stayman-Winesap, Grimes Golden, Baldwin, Red Delicious, Golden Delicious, Northern Spy and Rhode Island Greening apples have been processed for essence. The essences from McIntosh and Red and Golden Delicious apples were especially fragrant. All the other varieties yielded essences which were satisfactory when properly blended, with

the exception of Rhode Island Greenings, the essence from which did not possess an agreeable aroma.

Either a grater or a hammer mill may be used to grind the apples preparatory to pressing. To prevent fouling of the flavor-recovery equipment, the juice should be screened through a 60-, or finer, mesh screen. It is advantageous not to filter it at this stage, as some of the flavoring elements are eliminated by too complete clarification.

## Partial Vaporization of the Juice

It has been shown that the first 10 per cent of the juice vaporized contains all the volatile flavoring constituents. The heating and vaporizing must be done rapidly enough to avoid modification of the fresh flavor of both the juice and the essence. The total time should not exceed 15 seconds. The equipment best suited for this purpose is a single-pass rapid evaporator. The simplest unit is that of an evaporator tube without a pre-heater. As an example, an evaporator tube having an inside diameter of 0.62 inch and a heated length of 16½ feet will process 50 gallons per hour of juice, at a steam pressure of

GLASSED FOOD PRODUCTS such as those shown here may be among those to benefit from the new apple flavor essence whose manufacture is described in the accompanying article. Packs shown in this picture are packaged in glass containers by Anchor Hocking and Glass Containers, with closures by White Cap Co. and Crown Cork and Seal Corp.



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<sup>4</sup> "BLAND APPLE SIRUP," by H. H. Mottern and R. H. Morris, III, U. S. Department of Agriculture, Bureau of Agricultural and Industrial Chemistry, AIC-37. [Processed.]

<sup>5</sup> By "apple concentrate" is meant a material prepared by vacuum evaporation of apple juice without any alteration of its natural acid content; "apple sirup" signifies concentrated products whose natural acid content has been reduced.

# APPLE ESSENCE PRODUCTION EQUIPMENT

CAPACITY 1000 G.P.H. OF JUICE

FLOW DIAGRAM AND BASIC DATA

FURTHER DETAILS MAY BE OBTAINED FROM  
CHEMICAL ENGINEERING AND DEVELOPMENT DIVISION

EASTERN REGIONAL RESEARCH LABORATORY  
UNITED STATES DEPARTMENT OF AGRICULTURE  
PHILADELPHIA 18, PA.

PATENT APPLIED FOR

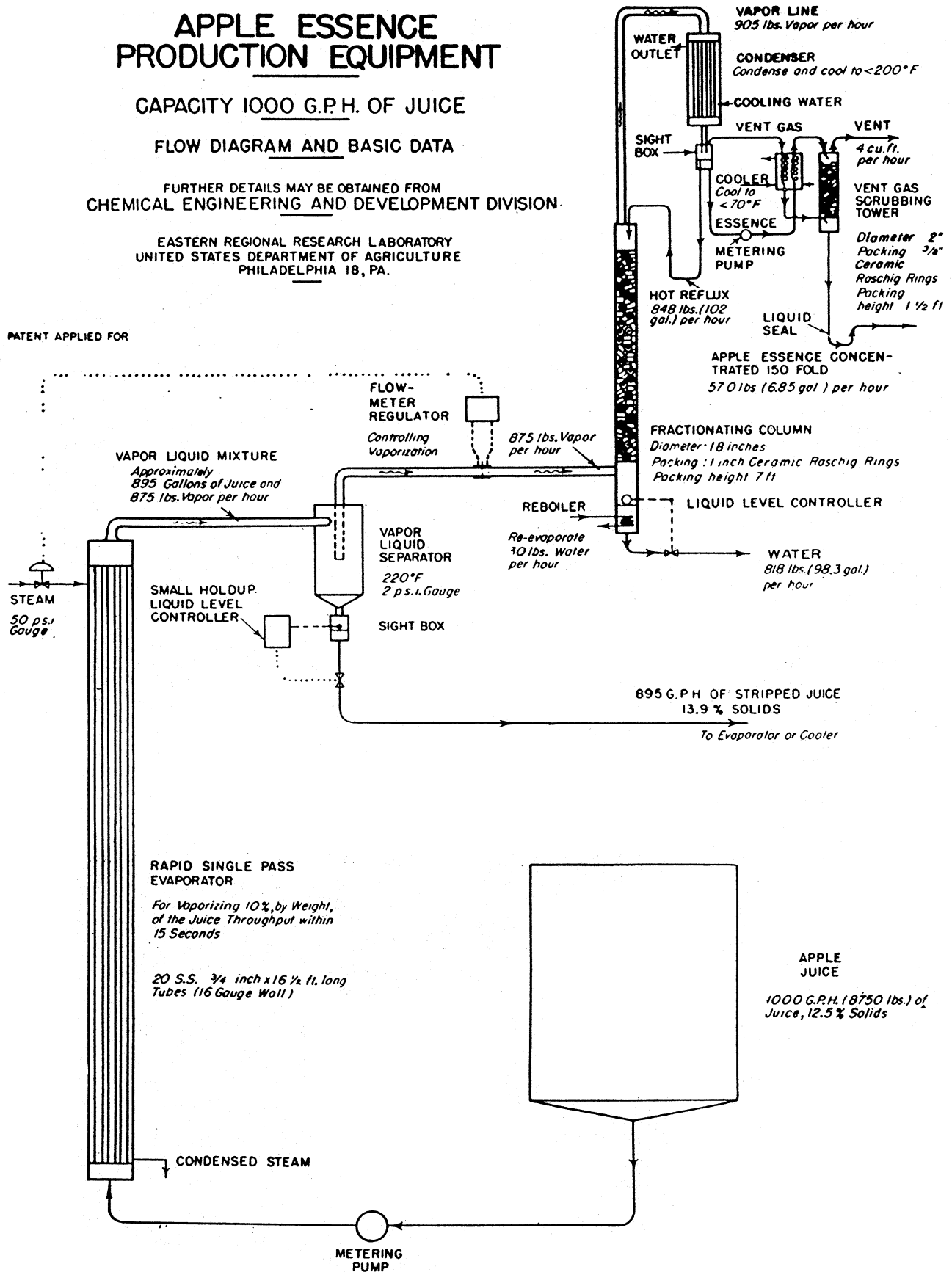


FIGURE ONE: Flowsheet of Apple Essence Production Equipment.

**FIGURE TWO:** Pilot-plant unit for recovery of Apple Essence at Eastern Regional Research Laboratory.

about 30 pounds per square inch in the jacket.

Under certain conditions, for example when the maximum steam pressure available is much less than 30 pounds per square inch, it may be desirable to employ a high-velocity preheater. However, when such a preheater with a tube of 0.18-inch inside diameter was used ahead of the evaporator described above and the time for preheating the juice to its boiling point as 2.0 seconds, the heating time permissible for vaporizing 10 per cent of the juice without modification of fresh flavor was only 8 seconds.

Fouling of the tubes of the evaporator system used either alone or with a preheater, by a pectin deposit is so slight that daily cleaning would probably be sufficient. Moreover, the fouling deposit may be removed by shutting off the steam, switching from juice feed to water, continuing water feed until the tubes are cool, then stopping the pumps and suddenly admitting steam to the steam chest. The boiling that takes place inside the tubes shortly thereafter removes the deposit. The whole operation requires only a few minutes.

#### **Separating the Vapors**

The vaporizing operation produces an intimate mixture of vapor and liquid, which must be separated. A small amount of entrained juice in the vapor can be tolerated, for the sugar and other solids which it contains will be subsequently removed in the fractionating column. Juice so entrained is lost for further processing, for it will be discarded as an extremely dilute solution in the bottoms product from the fractionating column.

#### **Fractionating the Vapors**

In the flashed vapors, the volatile flavoring constituents are present in a concentration approximately 10 times that of apple juice. The relatively dilute fraction thus obtained is difficult to utilize. For instance, its addition to the sirup of 80° Brix (approximately 80 per cent solids by weight) resulting from the evaporation of this apple juice would give a product of 50° Brix. This is less than that of commercial sirups, and would result in a product of poor keeping quality. The flashed vapors are therefore further concentrated in a fractionating column, as shown in Figure 1. When the flavor fraction is concentrated 100.-fold and then

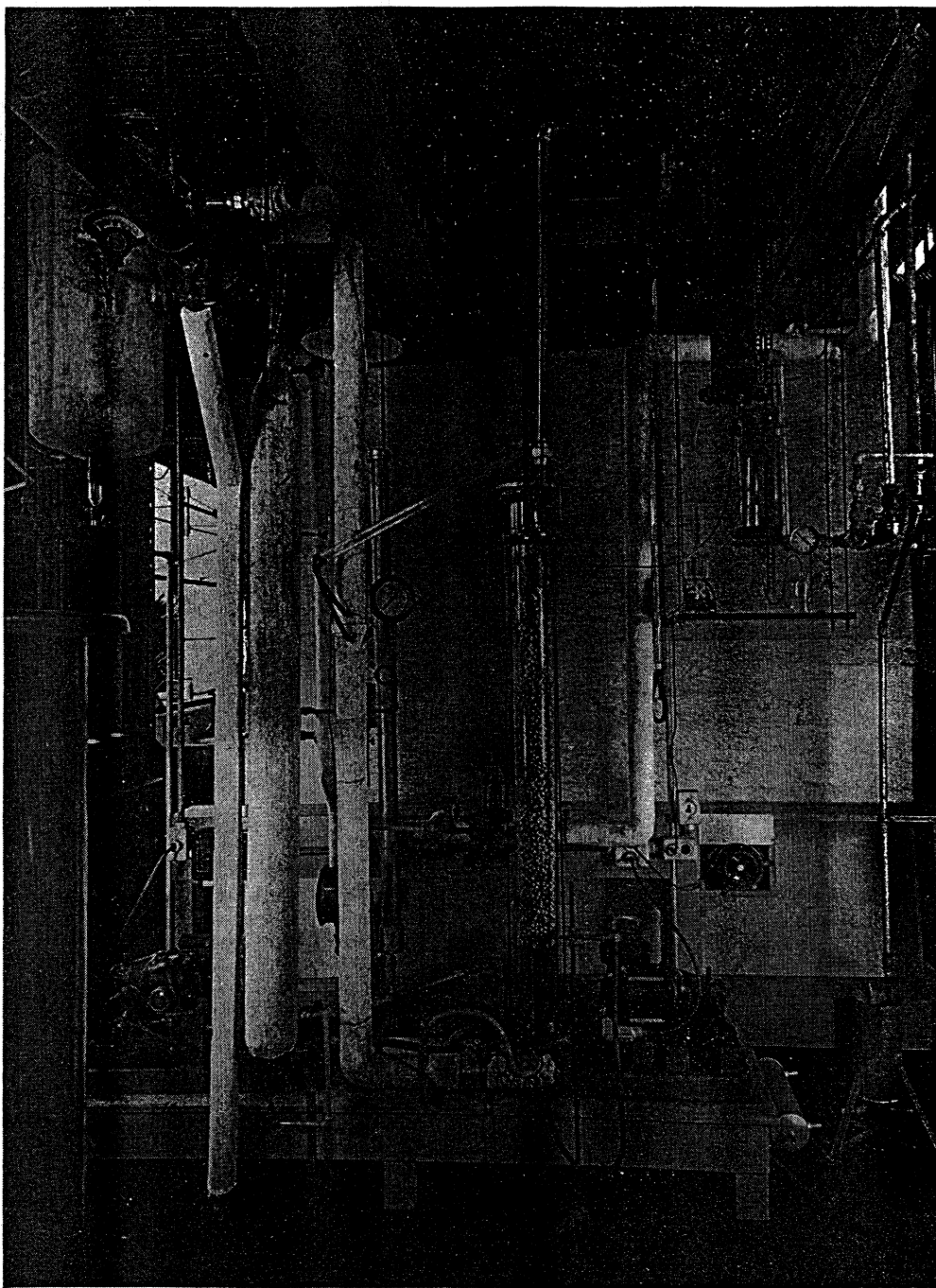
added to 80° Brix sirup, the resulting dilution is only 4.5° Brix. The fractional distillation is easily accomplished. In the pilot-plant studies, a depth of 3½ feet of porcelain Raschig rings of ¾-inch diameter was sufficient to effect a 15-fold increase in concentration of volatile flavoring constituents. Since a 10-fold concentration is achieved by vaporization, the total concentration achieved is 150-fold.

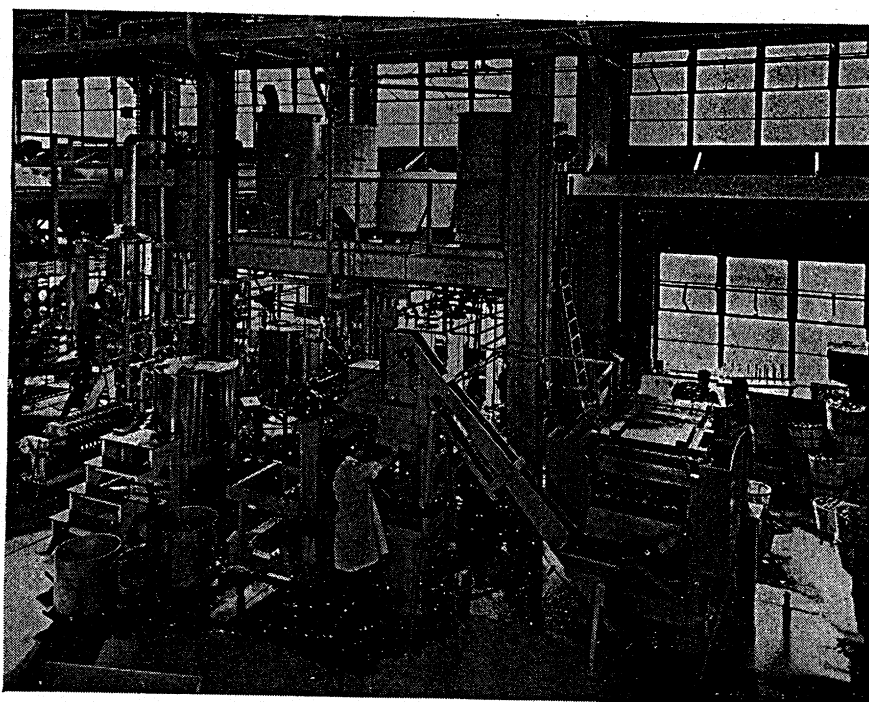
The vapors from the column pass to a condenser, where they are cooled to 200° F. or less. The product is withdrawn from the condensate receiver at a rate of 1/100 to 1/150 that of the juice feed rate, the remainder of the condensate being returned through an overflow as reflux to the column. In order to capture all the volatile flavoring constituents, both the vent gas from the condenser and

the essence withdrawn at condensate temperature are cooled to approximately 70° F. and then intermingled countercurrently in a small vent-gas scrubbing tower. The liquid withdrawn from the bottom of this tower is the essence which contains all the volatile constituents that were in the original juice.

#### **Operation and Control**

Operation and control of the process are rather simple. Two constant-rate liquid pumps, one on the fresh-juice feed line and the other on the product-discharge line, are set at predetermined rates as desired. For instance, to obtain a 150-fold concentration of flavor, the product pump is set at 1/150 the rate of the feed pump. For the proper operation of the evaporator, it is necessary to adjust the steam pressure on the





**FIGURE THREE:** Pilot-plant equipment for processing apples at Eastern Regional Research Laboratory.

USDA photos by M. C. Audsley.

evaporator so as to maintain a constant vaporization of 10 per cent of the juice entering the system. In small units this can be done satisfactorily by measuring the vaporized juice through an orifice in the vapor line between the separator and the fractionating column and manually adjusting the steam to the evaporator so that the pounds of vapor per minute flowing through this orifice corresponds to one-tenth that of the pounds per minute of juice entering the evaporator. In larger scale operations (Figure 1) it would be desirable to control the steam automatically by a flow-meter regulator in the vapor line between the vapor-liquid separator and the fractionating column. It would also be desirable to control the liquid level in the sight box under the vapor-liquid separator automatically as well as the liquid above the reboiler in the fractionating column.

### Equipment Required

The process for the production of apple essence would seem suitable for immediate adoption by present manufacturers of bland apple sirups and concentrates. The cost of steam for the continuous evaporator can be considered as chargeable to the manufacture of the sirup produced from the juice, because the concentration effected by this preliminary evaporation lessens the load on the sirup evaporators. The following equipment would be required for a unit having a capacity of 1,000 gallons per hour of juice, which is equivalent to 6.85 gallons per hour of 150-fold essence:

Juice-metering pump, capacity 1,000 gallons per hour.

Essence metering pump, capacity 6.85 gallons per hour.

Rapid single-pass evaporator with 20 stainless steel tubes, 3/4 inch O. D. x 16-1/2 feet long, 16 gauge wall.

Vapor-liquid separator.

Fractionating column, diameter 18 inches, packing height 7 feet, packed with 1 inch ceramic Raschig rings.

Condenser capable of condensing 905 pounds of water vapor per hour and cooling the condensate to approximately 200 degrees F.

Small coil cooler for chilling vent gas and essence from 200° to 70° F.

Vent-gas scrubbing tower, 2 inch diameter, packing height 1-1/2 feet, packed with 3/8 inch ceramic Raschig rings.

Flowmeter regulator for steam to evaporator.

Liquid-level controller for sight box beneath separator.

Liquid-level controller for water at base of fractionating column.

Miscellaneous piping and fittings.

Copper is generally considered a

### Significant Food Technology Report

This article, describing a means of separating and preserving the characteristic flavor of fresh apples, is of especial interest to

*Glass Packers* of apple juice, apple concentrate, fruit jellies;  
*Canners* of apples, applesauce, apple juice;

*Manufacturers* of ice cream and sherbets, beverages, confections;

*Concentrators* of fruit juices.

—THE EDITORS.

suitable material for apparatus in manufacturing apple sirup if the surface is kept bright, that is, not allowed to become oxidized by intermittent use. It should also be satisfactory for all the apparatus required for recovery of flavor except the parts of the evaporator coming in contact with the juice, or its vapors, and the metering pumps. The pumps may be bronze, but for the evaporator stainless steel is recommended.

Figure 2 shows the pilot plant equipment used at the Eastern Regional Research Laboratory for recovery of essence from apple juice. It has a capacity of approximately 50 gallons of juice per hour.

Figure 3 shows the laboratory's apple-processing equipment.

### Production Costs and Uses

The cost of adding the equipment for production of apple-essence to an existing apple-juice processing plant would depend upon available space in the plant, its location, and the suitability of present methods of washing and grading the apples. Assuming that the only additional equipment required is that shown in Figure 1, the investment in new equipment for processing 1,000 gallons of apple juice an hour would be about \$10,000. It is estimated that if the essence unit is operated for a hundred 8-hour days, the total cost of operating the essence unit would come to about a dollar per gallon of 150-fold essence. Such a plant would produce 45 to 50 gallons of the essence a day.

One of the most obvious uses of a natural apple flavor is in the manufacture of a concentrated juice from which a full-flavored, natural apple juice can be reconstituted by the addition of water. Such a product can be made by adding the recovered concentrated flavor to a suitable commercial apple juice concentrate; it is indistinguishable in taste and bouquet from the juice freshly pressed from the apples.

Since much of the apple juice evaporated commercially goes into products (vinegar and bland apple sirup) in which natural apple flavor is of no value the volatile flavoring constituents now discarded in the preparation of these products could by this new process be obtained in concentrated form and sold as a true apple essence. The essence has obvious uses in the preparation of sherbets, ices, fruit jellies and beverages.